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Environmental Effects of Dredging Technical Notes



A PRELIMINARY EVALUATION OF CONTAMINANT RELEASE AT THE POINT OF DREDGING

PURPOSE: The purpose of this technical note is to present a preliminary evaluation of the standard elutriate test as a predictor of contaminant release (dissolved form) to the water column at the point of dredging. This note is meant to extend previous notes (Hayes 1987, Havis 1987) which dealt with resuspension of sediments due to dredging and the release of adsorbed chemicals which could enter the water phase at the point of dredging.

BACKGROUND: Data collected under the Dredged Material Research Program (DMRP) showed that the standard elutriate test (Keeley and Engler 1974, US Environmental Protection Agency and US Army Corps of Engineers 1977, Environmental Effects Laboratory 1976) predicted, within an order of magnitude, dissolved chemical concentrations in water at dredged material disposal sites (Jones and Lee 1978). The potential for contaminant release also exists, however, at the point of dredging. This source of contaminant release during dredging was investigated by McLellan et al. (in preparation) under the Improvement of Operations and Maintenance Techniques (IOMT) program. Because of the success of the standard elutriate test for simulating dissolved contaminant release at the disposal site it was investigated as a tool for predicting contaminant release at the point of dredging.

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Introduction

Most of the sediments dredged to maintain the nation's navigation projects are clean, and the water quality impacts of dredging these clean

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sediments involve the temporary effects of turbidity caused by resuspended sediments. Although it has been estimated that less than 5 percent of the nation's maintenance materials are considered unacceptable for unconstrained open water disposal, the potential impacts of dredging in these sediments may involve toxicity from heavy metals and the effects of carcinogenicity and bioaccumulation from xenogeneic (man-made) organics such as polychlorinated biphenyls (PCBs). Developing methods for predicting the potential for contaminant release at the point of dredging is important to assure that dredging operations comply with state in-stream water quality standards where appropriate and to minimize potential adverse effects to aquatic systems.

Contaminant release at dredged material disposal sites has been studied under the DMRP effort, and preliminary work to describe contaminant release at the point of dredging has been done under the IOMT program. Work in the DMRP showed that chemical analysis of the bulk sediment is not appropriate for predicting the release of dissolved chemicals to the water column (Lee and Plumb 1974). Chemical release to the water column could be better evaluated by using a test that simulated the physical/chemical processes occurring in the field (Keeley and Engler 1974). These processes include the resuspension and mixing of sediment in the overlying water, subsequent settling of larger particles, and the gradual deposition of silts and clays. During the resuspension and settling process, however, chemicals that were sorbed to sediment particles may desorb into the water column.

Mechanisms for desorbing chemicals that then remain soluble are more complex than for chemicals that are strongly adsorbed to sediment particles. These particles are then quickly removed from the water column by gravity. Dissolved contaminants may be removed from the water column by mechanisms such as adsorption onto sediment particles which settle to the bottom, precipitation processes, redox transformations, uptake by aquatic life, degradation, and volatilization. Hence, because of the potential for dissolved chemicals to reside in the water column for a long period of time and the rapid availability of these contaminants to aquatic life, a predredging laboratory test such as the elutriate test may be necessary to evaluate the potential for dissolved chemical release at the point of dredging.

Methods

Standard elutriate test

The original elutriate test (Figure 1) (*Federal Register* 1973a, 1973b) was modified (*Federal Register* 1977, US Environmental Protection Agency and US Army Corps of Engineers 1977) to include the use of forced air for mixing. Standard procedures for the test specify that 20 percent by volume of undisturbed sediments be mixed with 80 percent by volume of water from the dredging site. Agitation by mechanical mixing for 1/2 hr and release of compressed air through a diffusing stone simulates mixing and aeration by hydraulic pipeline dredging. The mixture is allowed to settle for 1 hr. The supernatant is collected and filtered through a 0.45-micron filter and analyzed for chemicals of concern.

Field work

The data presented in this note were taken from four dredging sites located at Black Rock Harbor, near Bridgeport, Conn.; Calumet Harbor, near Chicago, Ill.; the Duwamish River, near Seattle, Wash.; and the James River, near Jamestown, Va. These data were obtained as a part of the larger IOMT

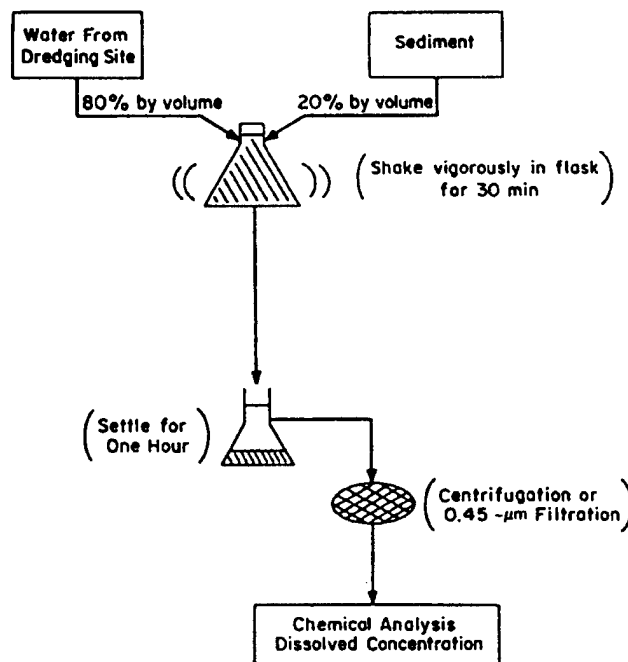


Figure 1. Standard elutriate test

data collection effort to characterize the sediment resuspension and contaminant release characteristics of selected dredges (McLellan et al., in preparation). Table 1 summarizes the conditions at the field sites and the types of dredging equipment used.

Evaluation of the standard elutriate test predictions

Predredging sediment samples were taken in the dredging area for laboratory analysis by the standard elutriate test. During dredging, samples were taken near the bottom of the water column for chemical analysis of soluble (<45 μ m) forms. The samples were taken within a few feet of the operating dredge head in the case of hydraulic dredging and within 50 ft of the dredge in the case of mechanical dredging. The dissolved chemical concentrations measured in the water column near the dredge were compared with the corresponding concentrations measured in samples obtained from standard elutriate tests.

Results

Black Rock Harbor

Sediment sampling for elutriate testing was conducted on 2 May 1985, and water-column sampling during the clamshell dredging operation was conducted on 5 and 6 May 1985. Figure 2 shows the results of chemical analyses on dredging site water-column samples and standard elutriate test samples. The average values shown represent means of three measured chemical concentrations. Where equal values (equal-length bars) are shown for water column and elutriate test results, as is the case for cadmium and arsenic, the chemical concentrations were too low for the instrumentation to detect and therefore the instrument detection limit is shown.

The elutriate test predicted within one order of magnitude the chemical concentrations measured in the water column at the dredging site (Figure 2). Chemical species of metals were predicted best and total phosphorus and the ammonium ion (NH_4^+) were predicted with less accuracy. Based upon these results, the standard elutriate test is a conservative predictor of chemical concentrations at this dredging site since laboratory values were consistently higher than those measured in the field water-column samples.

Table 1
Summary of Field Site Conditions

Study	Dredge Plant	Site Conditions	Sediment Characteristics	Current Range ft/sec	Background Total Suspended Solids (TSS) Concentration mg/l		Maximum TSS/ Background TSS
					Surface	Bottom	
Black Rock Harbor	Open Clamshell (10 yd ³)	Estuary (10-21 ppt)	Sandy, organic clay 90% fines, LL = 170 PI = 65	0.2-0.8	45	69	15.9
Calumet Harbor	Cutterhead (12-in)	Freshwater lake	Soft organic clay/silt, OH, 80% fines sp gr = 2.71	0-0.2	2	5	2.0
Duwamish Waterway	Open clamshell	Estuary (12-21 ppt)	Sandy clayey silt (MH)	0.3-1.1	11	26	6.1
James River	Cutterhead	Estuary	Silty clay (CH) LL = 120, PI = 80	0.5-2.3	42	86	3.8

Note: LL = liquid limit; PI = plasticity index; and sp gr = specific gravity. Soil classification is by the Unified Soil Classification System.

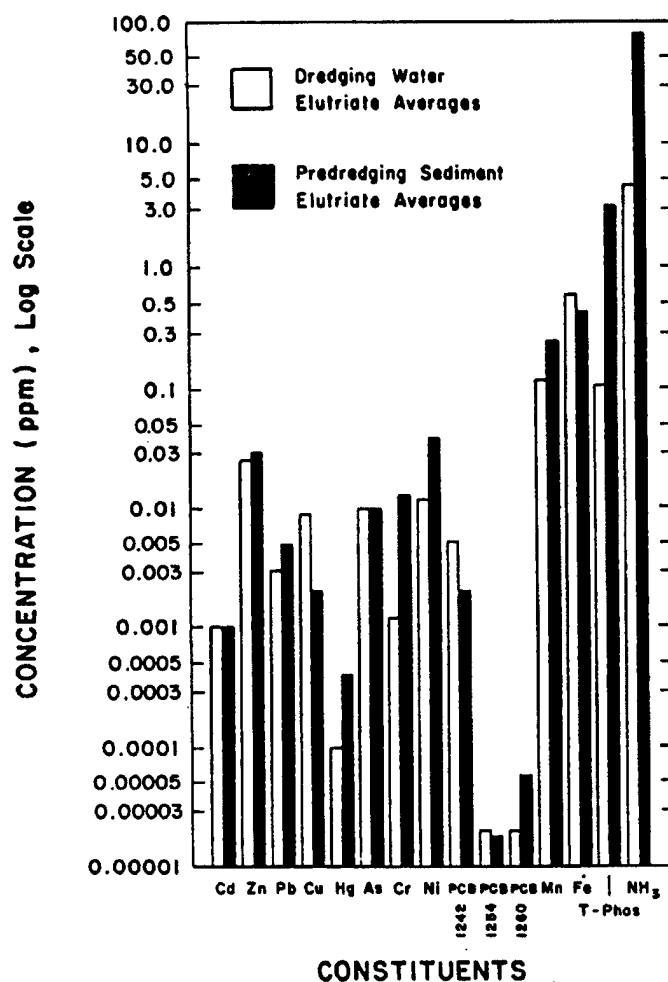


Figure 2. Comparison of average dissolved chemical concentrations from elutriate testing and from dredging site water-column measurements at Black Rock Harbor

Calumet Harbor

Elutriate test samples were taken at the Calumet River on 20 August 1985, and water-column samples were taken during cutterhead dredging in approximately 27 ft of water on 22 and 23 August 1985. Figure 3 summarizes the results of chemical determinations on six water-column samples and four replicated elutriate test samples. The equal-length bars for cadmium (Cd), (Cu), chromium (Cr), nickel (Ni), and PCB indicate that the detection limit of the instrumentation was reached. The water-column zinc (Zn) concentration was greater than was predicted from the elutriate test but both zinc concentrations were within one order of magnitude. The elutriate test failed to fall

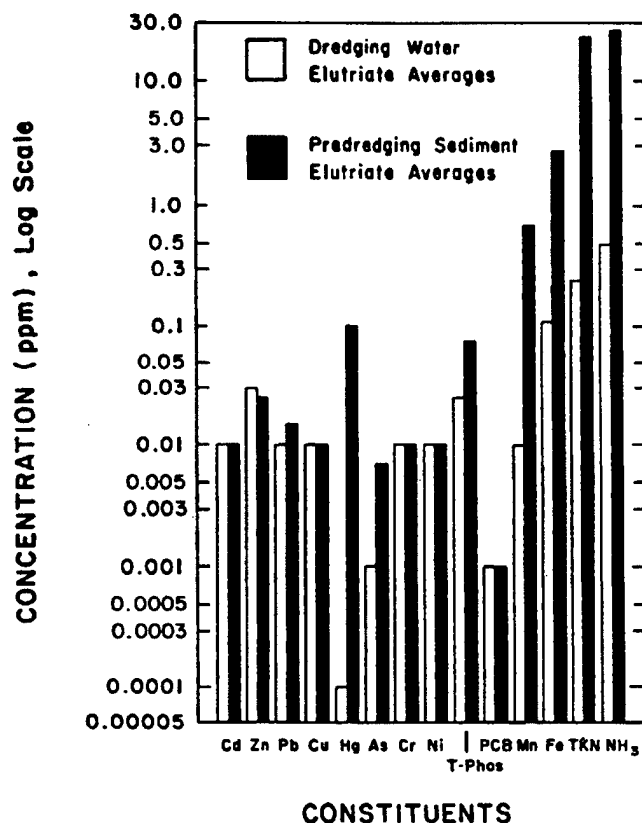


Figure 3. Comparison of average dissolved chemical concentrations from elutriate testing and from dredging site water-column measurements at Calumet River

within one order of magnitude of the water-column measurements in the cases of mercury (Hg), manganese (Mn), iron (Fe), total Kjeldahl nitrogen (TKN), and ammonia (NH₃). However, since the elutriate test values were greater than the water-column values the test was again a conservative predictor of the dredging site concentrations of these chemicals.

Duwamish Waterway

Sediment samples for elutriate testing were collected on 24 and 25 March 1984, and water-column samples during clamshell dredging were collected from a sampling position on the dredge on 26 March 1984. Figure 4 shows the average chemical concentration from the three dredging site water-column samples and averages of four replicated elutriate test samples. Water-column samples from the dredging site were higher in concentrations of Zn and lead (Pb) than was predicted from elutriate testing (Figure 4), but values were within an order

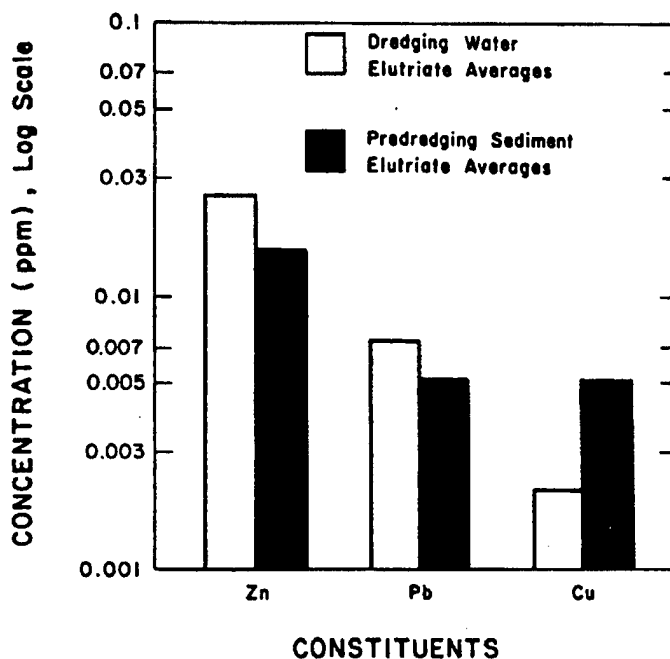


Figure 4. Comparison of average dissolved chemical concentrations from elutriate testing and from dredging site water-column measurements at the Duwamish Waterway

order of magnitude. Copper concentration at the dredging site was over-estimated or conservatively predicted by the elutriate test.

James River

Bender et al. (1984) gives a detailed study of the application of the elutriate test as a predictor of dredging site chemical concentrations in the James River. The comparisons of the standard elutriate test results and chemical determinations on dredging site water-column samples (Figure 5) showed that Zn, Pb, Cu, and total phosphorus (T-Phos) were predicted within an order of magnitude and TKN predictions were more than an order of magnitude greater than the field measurements. Cadmium levels were too low to be detected in either the elutriate test water or at the dredging site.

Conclusions

The standard elutriate test was shown to predict dredging site water-column chemical concentrations, within an order of magnitude, for most chemicals in the four studies presented. Therefore, as a preliminary evaluation

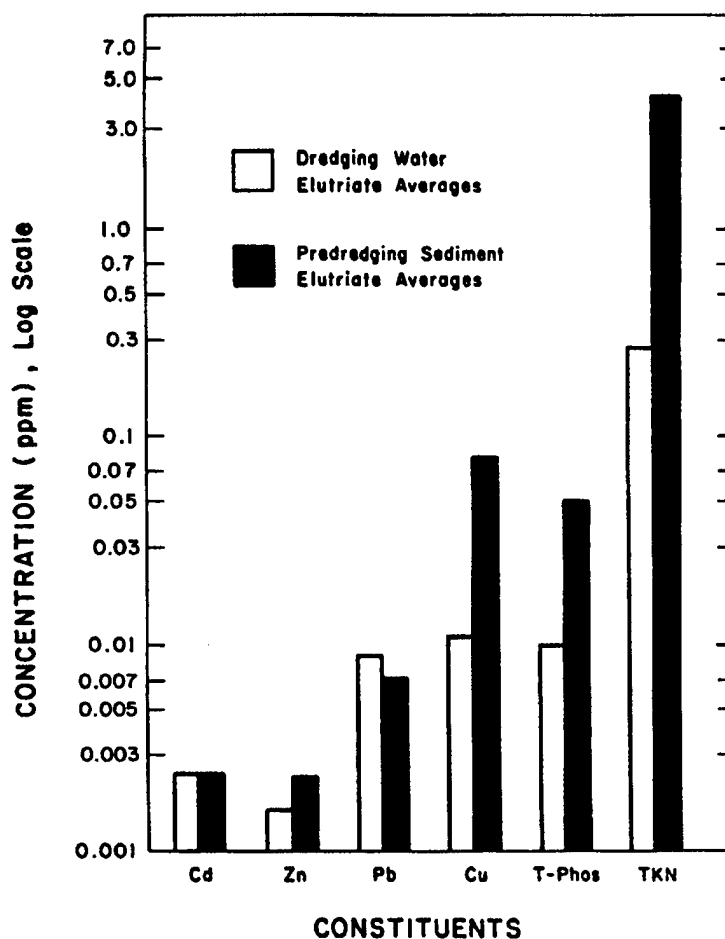


Figure 5. Comparison of average dissolved chemical concentrations from elutriate testing and from dredging site water-column measurements at the James River

the standard elutriate test is deemed worthy of further study as a predictor of dredging site water-column chemical concentrations. In some cases, however, dredging site water-column chemical concentrations were more than an order of magnitude lower than the corresponding elutriate test results. In the few cases where the standard elutriate test predicted lower chemical concentrations than were found at the dredging site, the estimates were within an order of magnitude of the dredging site water-column chemical concentrations. In general, the standard elutriate test was shown to be a conservative predictor of dredging site dissolved chemical concentrations for most of the chemicals tested.

Future Directions

Since the standard elutriate test gave reasonable predictions of dredging site water-column chemical concentrations, confidence was gained in the general applicability of the test for predictions of chemical water quality at the point of dredging. The study by Bender et al. (1984) suggested that modifying the standard elutriate test by reducing the solids-to-water ratio and reducing the mixing time could provide more reasonable results for hydrophobic chemicals and possibly TKN. Bender and his colleagues experimented in the laboratory with low solids to dredging site water ratios and with modification of mixing times to both simplify the standard elutriate test procedure and as an attempt to better simulate field TSS concentrations in the laboratory. They concluded that a shorter mixing time and smaller sediment-to-water ratio would produce more accurate elutriate test predictions for hydrophobic chemical compounds and for TKN. Phosphorus, however, was still overestimated and the modifications to the elutriate test did not significantly change the accuracy of metal concentration estimates. However, the work by Bender et al. (1984) and the general applicability of the standard elutriate test for predicting chemical water quality at high sediment concentrations suggest that modifications to the solids-to-water ratio for simulating expected dredging site conditions should be investigated to achieve more accurate predictions.

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